**Page**

**Page**

# 2.0 Preliminary Design

## 2.1 Preliminary Studies

### 2.1.1 Interdisciplinary Design Studies

As part of the preparation for a major project, an Interdisciplinary Design Team (IDT) may be established by the region. The IDT is composed of members of different expertise and backgrounds, selected from regions, the Service Center, and outside agencies. The IDT members and the support groups serve to give an objective analysis and review of the various design alternatives for the region's project. They contribute ideas and participate in the selection of design alternatives. This work will often culminate in the publication of the Environmental Impact Statement (EIS).

Bridge Design Engineers are often asked to be a part of this process, either as a support resource or as a member of the IDT itself.

### 2.1.2 Value Engineering Studies

Value Engineering (VE) is a process of review and analysis of a project. The VE team seeks to define the most cost-effective means of satisfying the basic function(s) of the project. Usually a VE study takes place before or during the time that the region is working on the design. Occasionally a VE study examines a project with a completed PS&E.

A VE team is typically made up of members of different expertise and backgrounds, selected from the region, Service Center, and outside agencies. The Team Facilitator will lead the team through the VE process. The team will review the project as defined by the project's design personnel. They will seek to decide the basic function(s) that are served by the project, brainstorm to develop other alternatives to serve the same function(s), and evaluate these alternatives on how well they satisfy these basic functions. The VE team will present their findings in a presentation to the region. The region is then required to investigate these findings further and address them in the design.

Bridge Design Engineers are often asked to be a part of this process, either as support contacts or as VE team members. The process usually involves three to five days.

### 2.1.3 Preliminary Project Recommendations (Existing Bridges)

Projects that call for the rehabilitation of an existing bridge require that the existing condition of the bridge be reviewed and a recommendation the existing bridge be prepared. When a region starts a design for such a project, they will request by an Inter-Departmental (IDC) memorandum that the Bridge and Structures Office make Preliminary Project recommendations. This will provide them with a scope of work and a cost estimate for the project. It involves review of the inspection and condition reports from the Bridge Preservation Section and a site visit with the region and other project stakeholders. Special inspections of certain portions of the structure may need to be scheduled to determine the load capacity of the existing bridge, what types of rehabilitation work need to be done, the extended life span achieved by certain types of rehabilitation work, and to develop various alternatives with cost estimates for comparison, ranging from "do nothing" to "replacement."

A typical recommendation consists of two parts. The first is a report to the file providing detailed information related to the bridge rehabilitation and a summary of the various alternatives considered and an itemized list of the rehabilitation work with the associated costs. The second part is an IDC to the region discussing the overall project in general terms mentioning any particular items of concern to the region and a summary of the preferred alternatives with recommendations. The region should be given the opportunity to review a draft report and IDC and provide input prior to finalization.

### 2.1.4 Preliminary Project Recommendations (New Bridges)

Projects that call for a new bridge require that a recommendation for the new structure be prepared. While a region is preparing a design for a project, they will seek assistance from the Bridge and Structures Office by writing an IDC. This request could range from confirmation of construction cost data to consideration of various structure designs or staging alternatives. An IDC to the region will provide recommendations and information. A face to face meeting with the region project staff is recommended.

### 2.1.5 Type, Size, and Location Studies

It is the policy of the Federal Highway Administration (FHWA) that major or unusual bridges must go through the preparation of a Type, Size, and Location (TS&L) study. The TS&L study will outline the project, describe the proposed structure and other design alternatives considered, and show justification for the selection of the preferred alternative. Approval of the TS&L study by FHWA is the basis for advancing the project to the design stage.

The FHWA requires a TS&L study for tunnels, movable bridges, unusual structures, and major structures with deck areas greater than 125,000 square feet. This is a guideline only. Smaller bridges that are unusual may also require a TS&L study while some, such as long viaducts, may not. As early as possible in the Project Development stage, the FHWA should be contacted for conformation.

The preparation of the TS&L study is the responsibility of the Bridge and Structures Office. The TS&L cannot be submitted to FHWA until after the Environmental documents have been submitted. However, TS&L preparation need not wait for Environmental document approval, but may begin as soon as the bridge site data is available. See Chapter 1110 of the *Design Manual* for the type of information required for a bridge site data submittal.

A. TS&L General

In order to become familiar with the project, the designer should first review its history. The Environmental and Design Reports should be reviewed. The bridge site data should be scrutinized so that additional data, maps, or drawings can be requested. After reviewing the history of the project, a meeting with region and a site visit should be arranged.

In order to have foundation information, the Materials Lab must be contacted early. FHWA expects specific recommendations on the foundation type. The Materials Lab will submit a detailed foundation report for inclusion as an appendix to the TS&L study.

In order to find the preferred structural alternative, the designer should:

1. Develop a list of all the feasible alternatives. At this stage of the process, the range of alternatives should be kept wide open. Brainstorming with supervisors and other engineers can help bring out fresh and innovative solutions.
2. Eliminate the unusable alternatives by applying the constraints of the project. Question restrictive constraints and document their bases. At the end of this step, there should be no more than four alternatives.
3. Perform preliminary level design calculations for unique structural problems to ensure that the remaining alternatives are feasible.
4. Compare the advantages, disadvantages, and costs of the remaining alternatives to determine the preferred alternative(s).
5. Visit the project site with the region and Geotech Branch.

After piers have been located, a memorandum request for a Hydraulics Report should be made to the Olympia Service Center Hydraulics Unit. FHWA expects specific information on scour and backwater on both falsework and permanent piers. The Olympia Service Center Hydraulics Unit will submit a report for inclusion as an appendix to the TS&L study.

The Bridge Architect at the Bridge and Structures Office should be consulted early on and throughout the study process "Notes to the file" should be made documenting the aesthetic requirements and recommendations of the Architect.

Cost backup data is needed for any costs used in the TS&L study. FHWA expects TS&L costs based on estimated quantities. This data is to be included in an appendix to the TS&L study. It is a good idea to coordinate the quantities submitted are in a form compatible with the estimator's cost breakdown method.

B. TS&L Outline

The TS&L study should describe the project, the proposed structure, and give reasons why the bridge type, size, and location were selected.

1. Cover, Title Sheet, and Contents

These should identify the project and the contents of the TS&L.

2. Photographs

There should be enough color photographs to provide the look and feel of the area. The prints should be numbered and labeled and the location indicated on a diagram.

3. Introduction

The introduction describes the report and references other reports used to prepare the TS&L study. The following reports should be listed if used.

- Design Reports and Supplements
- Environmental Reports
- Architectural or Visual Assessment Reports
- Hydraulic Report
- Geotechnical Reports

4. Project Description

The project description is intended to summarize the preferred alternative of the project design so that the TS&L study clearly defines the project. Care should be taken to describe the project adequately but briefly. A vicinity map should be shown.

5. Design Criteria

Design criteria states to what code, loading, etc., the bridge will be constructed. Besides the AASHTO specifications and assorted AASHTO guide specifications, other criteria are sometimes used. These criteria should be listed. Examples of this would be the temperature loading used for segmental bridges or areas defined as wetlands.

6. Structural Studies

   The structural studies section documents how the proposed structure type, size, and location were determined. The following considerations should be addressed.

   - Aesthetics
   - Cost Estimates
   - Geometric constraints
   - Project staging
   - Foundations
   - Hydraulics
   - Feasibility of construction
   - Structural constraints
   - Maintenance

   This section should have a narrative style describing how these factors point to the preferred alternative. Show how each constraint eliminated or supported the alternatives. For instance, "Because the geometry required a 200-foot span, prestressed concrete girders could not be used" or "Restrictions on falsework placement forced the use of self supporting precast concrete or steel girders."

7. Executive Summary

   The executive summary should be able to stand alone as a separate document. The project and structure description should be given. Present the recommended alternative with its cost and include a summary of considerations used to choose or eliminate alternatives.

8. Drawings

   Preliminary Plan drawings of the recommended alternative are included in the appendix. The drawings show the plan, elevation, and typical section. For projects where alternative designs are specified as recommended alternatives, Preliminary Plans for each of these structure types shall be included. Supplemental drawings showing special features, such as complex piers, are often provided to clearly define the project.

C. Reviews and Submittal

While writing the TS&L study, all major decisions should be discussed with the unit supervisor, who can decide if the Bridge Design Engineer needs to be consulted. A peer review meeting with the Bridge Design Engineer should be scheduled at 50 percent completion. The FHWA Bridge Engineer should be invited to provide input.

The final report must be reviewed, approved, and the Preliminary Plan drawings signed by the Bridge Architect, the Bridge Projects Engineer, the Bridge Design Engineer, and the Bridge and Structures Engineer. The TS&L study is submitted with a cover letter to FHWA signed by the Bridge and Structures Engineer.

## 2.2 Preliminary Plan

The Preliminary Plan is the most important phase of bridge design as it sets the groundwork for the final design. The intent is to completely define the bridge geometry so final roadway design by the regions and the structural design by the Bridge and Structures Office can take place with minimal revisions.

During the region's preparation of the highway design, they also begin work on the bridge site data. Region submits the bridge site data to the Bridge and Structures Office which initiates the start of the Preliminary Plan. Information that must be included as part of the bridge site data submittal is outlined in Chapter 1110 of the *Design Manual.*

### 2.2.1 Development of the Preliminary Plan

A Responsibilities

In general, the responsibilities of the designer, checker, detailer, and supervisor are as specified in Chapter 1 of the *Bridge Design Manual.* The primary design engineer is responsible for developing a Preliminary Plan for the structure that is compatible with geometric, aesthetic, staging, geotechnical, hydraulic, financial, and structural requirements and conditions that exist at the site.

Upon receipt of the bridge site data from the region, the designer shall review it for completeness and verify that what the project calls for is realistic and structurally feasible. Any omissions or corrections are to be called to the region's attention immediately.

The supervisor shall be kept informed of progress on the preliminary plan so that the schedule can be monitored. Should problems develop, the supervisor can make adjustments to the schedule or manpower assignments. The designer must keep the job file up to date by documenting all conversations, meetings, requests, questions, and approvals concerning the project. Notes to the designer, and details not shown in the Preliminary Plan shall be documented in the job file.

The checker shall give an independent review of the plan, verifying that it is in compliance with the site data as provided by the region and as corrected in the job file. The plan shall be compared against the Preliminary Plan checklist to ensure that all necessary information is shown. The checker is to review the plan for consistency with office design practice, detailing practice, and for constructibility.

The preliminary plan shall be drawn using current office CAD equipment and software by the Engineer or Detailer.

B. Site Reconnaissance

The site data submitted by the region will include a video and photographs of the site. Even for minor projects, this may not be enough information for the designer to work from in developing the Preliminary Plan. For most bridge projects, site visits are necessary. Site visits with region project staff and other project stakeholders such as Hydraulics, Design, and Geotech Branch should be arranged with the knowledge and approval of the Bridge Projects Engineer.

C Coordination

The designer is responsible for coordinating the design and review process throughout the project. This includes seeking input from various WSDOT units and outside agencies.

D. Consideration of Alternatives

In the process of developing the Preliminary Plan, the designer should brainstorm, develop, and evaluate various design alternatives. Depending on how the General Factors for Consideration (Section 2.2.3) apply to a particular site, the number of alternatives will usually be limited to only a few for most projects. For some smaller projects and most major projects, design alternatives merit development and close evaluation. The process of considering and rejecting design alternatives provides documentation for the preferred alternative.

E. Designer Recommendation

Once the designer has done a thorough job of evaluating the needs and limitations of the site, analyzed all information and developed and evaluated design alternatives for the project, he should be able to make a recommendation for the optimum solution. Based on this recommendation, the designer should discuss the recommendation with the Bridge Projects Engineer.

F. Concept Approval

For some projects, the presentation, in "E" above, to the Bridge Projects Engineer will satisfy the need for concept approval. Large complex projects, projects of unique design, or projects where two or more alternatives appear viable, should be presented to the Bridge Design Engineer for his concurrence before plan development is completed. For unique or complex projects a presentation is made to the Bridge and Structures Office Peer Review Committee.

G. Inspection and Maintenance Access

In the process developing the Preliminary Plan, the design engineer should consult with the Bridge Preservation Section for input.

### 2.2.2 Documentation

A. Job File

When a memorandum IDC, transmitting site data from the region is received by the Bridge and Structures Office, a job file is created. This official job file serves as a depository for all communications and resource information for the job. Scheduling and time estimates are logged in this file, as well as cost estimates, preliminary quantities, and documentation of all approvals.

When the Preliminary Plan is completed, the job file continues to serve a useful purpose as a communications and documentation depository for all pertinent project-related information during the design process.

B. Bridge Site Data

All Preliminary Plans are developed from site data as submitted by the region. This submittal will consist of a memorandum IDC, and appropriate attachments as specified by Chapter 1110 of the *Design Manual*. When this information is received, it should be reviewed for completeness so that missing or incomplete information can be noted and requested.

C. Request for Preliminary Foundation Data

A Request for Preliminary Foundation Data is sent to Geotech Branch to solicit any foundation data that is available at this preliminary stage. The Geotech Branch is provided with approximate dimensions for overall structure length and width, an approximate number of intermediate piers (if applicable), and approximate stations for beginning and end of structure on the alignment.

Based on test holes from previous construction in the area, geological maps, and soil surveys. The Materials Lab responds by IDC giving an analysis of what foundation conditions arc likely to be encountered and what types of substructure are best suited for these conditions.

D. Request for Preliminary Hydraulics

A Request for Preliminary Hydraulics data is sent to the Hydraulics Office to document hydraulic requirements that must be considered in the structure design. The Hydraulics Office is provided with the contour plan and other bridge site data.

Seal vent elevations, normal water, 100-year flood and 500-year flood elevations, and flows (Q), pier configuration, scour depth and minimum footing cover, ice pressure, minimum waterway channel width, riprap requirements, and minimum clearance to the 100-year flood elevation are provided in an °IDC response from the Hydraulics Office.

E. Design Report or Design Summary

Some bridge construction projects have a Design Report or Design Summary prepared by the region. This is a document which includes design considerations and conclusions reached in the development of the project. It defines the scope of work for the project. It serves to document the design standards and applicable deviations for the roadway alignment and geometry. It is also an excellent reference for project history, safety and traffic data, environmental concerns, and other information.

F. Other Resources

For some projects, preliminary studies or reports will have been prepared. These resources can provide additional background for the development of the Preliminary Plan.

G. Notes if meetings with Regions and other project stakeholders shall be included in the documentation.

### 2.2.3 General Factors for Consideration

Many factors must be considered in preliminary bridge design. Some of the more common of these are listed in general categories below. These factors will be discussed in appropriate detail in subsequent portions of this manual.

A. Site Requirements

Topography Alignment (tangent, curved, skewed)
Vertical profile and superelevation
Proposed or existing utilities

B. Safety

Feasibility of falsework (impaired clearance and sight distance)
Density and speed of traffic
Detours or possible elimination of detours by staging construction
Sight distance
Horizontal clearance to piers
Hazards to pedestrians, bicyclists
Inspection and Maintenance Access (UBIT clearances) (see Figure 2.3.10-1)

C. Economic

Funding classification (federal and state funds, state funds only, local developer funds)
Funding level

D. Structural

Limitation on structure depth
Requirements for future widening
Foundation and groundwater conditions
Anticipated settlement

E. Environmental

Site conditions (wetlands, environmentally sensitive areas)
EIS requirements
Mitigating measures

F. Aesthetic

General appearance
Compatibility with surroundings and adjacent structures
Visual exposure and importance

G. Construction

Ease of construction
Falsework clearances and requirements
Erection problems
Hauling difficulties and access to site
Construction season
Time limit for construction

H. Hydraulic

Bridge deck drainage
Stream flow conditions and drift
Passage of flood debris
Scour, effect of pier as an obstruction (shape, width, skew, number of columns)
Bank and pier protection
Consideration of a culvert as an alternate solution
Permit requirements for navigation and stream work limitations

I. Other

Prior commitments made to other agency officials and individuals of the community
Recommendations resulting from preliminary studies

## 2.2.4 Permits

A. Coast Guard

As outlined in Chapter 240 of the *Design Manual*, the Bridge and Structures Office is responsible for coordinating and applying for Coast Guard permits for bridges over waterways. This is handled by the Coast Guard Liaison Engineer in the Bridge Projects Unit of the Bridge and Structures Office.

A determination of whether a bridge requires a permit is known before the bridge site data is received. Generally, tidal-influenced waterways and waterways used for commercial navigation will require Coast Guard permits. However, some waterways may qualify for an exemption from a permit if certain conditions apply including the exclusion of use by vessels larger than 21 feet long. The process of getting this exemption, from FHWA, not the Coast Guard, is the responsibility of the region. The Coast Guard Liaison Engineer should be asked to check with the region and the Coast Guard to confirm the situation on a case by case basis.

For all waterway crossings, the Coast Guard Liaison Engineer is required to initial the Preliminary Plan as to whether a Coast Guard permit or exemption is required. This box regarding Coast Guard permit status is located in the center left margin of the plan. If a permit is required, the permit target date will also be noted. The reduced print, signed by the Coast Guard Liaison Engineer, shall be placed in the job file.

The work on developing the permit application should be started such that it is ready to be sent to the Coast Guard eight months before the project ad date. The Coast Guard Liaison Engineer should be given a copy of the Preliminary Plan from which to develop the plan sheets that are part of the permit.

B. Other

All other permits will be the responsibility of the region. The Bridge and Structures Office may be asked to provide information to the region to assist them in making applications for these permits.

### 2.2.5 Approvals

A. Bridge Design

When the Preliminary Plan has been checked by the checker and signal by the Bridge Projects Engineer, it is ready to go to the Bridge Design Engineer and the Bridge and Structures Engineer for approval.

B. Bridge Architect/Specialists

For all preliminary plans, the Architect/Specialists should be aware and involved when the designer is first developing the plan. The Architect/Specialists should be presented with a reduced print of the plan by the designer. This is done prior to the job going to the checker. The Architec/Specialistst will review the print and signify their approval by signing it. This print is placed in the job file. If future plan revisions change elements of aesthetic importance, the Architect should be asked to review and approve, by signature, a print of the revised plan.

For large, multiple bridge projects, the Bridge Architect should be contacted for development of a coordinated architectural concept for the project corridor. The architectural concept for a project corridor is generally developed in draft form and reviewed with the project stakeholders prior to finalizing.
In order to ahieve superstructure type optimization and detailing consistency, the following guidelines shall be used for the preparation of all future Preliminary Plans:

- Preliminary Plans for all steel bridges and structures shall be reviewed by the steel specialists.
- Preliminary Plans for all concrete bridges and structures shall be reviewed by the concrete specialist.
- Detailing of all Preliminary Plans shall be reviewed by the PreliminaryPlans Detailing Specialists.

These individuals shall sign off in the Architect/Specialist block in the plan sheets, together with the Architect. Once the Preliminary Plans have been checked and the Bridge Projects Engineer has given final approval, the Preliminary Plans along with a cover memo goes to the Bridge Design Engineer and Bridge Structure Engineer for approval before distribution.

C. Region

Prior to the completion of the preliminary plan the designer should meet with the region to discuss the concept and get their input. When the Preliminary Plan and the "Not Included in Bridge Quantities List" along with the preliminary plan transmittal IDC.

The region will review the plan for compliance and agreement with their original site data. They will work to answer any notes to the region that have been listed on the plan. When this review is complete, the Regional Administrator, or his representative, will sign the plan. The region will send back a print of the plan with any comments noted in red (additions) and green (deletions) along with responses to the notes to the region.

D. Railroad

When a railroad is involved with a structure on a Preliminary Plan, the Right of Way Accommodation Engineer of the Design Office must be involved during the plan preparation process. A copy of the Preliminary Plan is sent to the Right of Way Accommodation Engineer, who then sends a copy to the railroad involved for their comments and approval.

The railroad will respond with approval by letter to the Right of Way Accommodation Engineer. A copy of this letter is then routed to the Bridge and Structures Office and is placed in the job file.

## 2.3 Preliminary Plan Criteria

### 2.3.1 Highway Crossings

A. General

A highway crossing is defined as a grade separation between two intersecting roadways. A highway crossing is further categorized as either an undercrossing or an overcrossing.

1. Undercrossing

A bridge which provides for passage of a state highway under a less important state highway, a county road, or a city street is called an undercrossing. Relative importance between state highways is indicated by functional classification. For details, see Chapter 440 of the *Design Manual*.

For example, a bridge included as a part of an interchange involving SR 182 (Interstate) and SR 14 (Principal) and providing for passage of traffic on SR 182 under SR 14 would be called SR 14 I/C Undercrossing.

2. Overcrossing

A bridge which carries traffic on a state highway over a less important state highway, a county road, or a city street is called an overcrossing.

For example, a bridge which carries traffic on SR 5 over Hamilton Road would be called Hamilton Road Overcrossing.

B. Bridge Width

The bridge roadway channelization is provided by the region with the Bridge Site Data. For state highways, the roadway geometrics are controlled by Chapters 430 and 440 of the *Design Manual*. For city and county arterials, the roadway geometrics are controlled by Chapter IV of the *Local Agency Guidelines*.

C. Horizontal Clearances

Safety dictates that fixed objects be placed as far from the edge of the roadway as is economically feasible. Criteria for minimum horizontal clearances to bridge piers and retaining walls are outlined in the *Design Manual*. Chapter 710 of the *Design Manual* outlines clear zone and recovery area requirements for horizontal clearances without guardrail or barrier being required.

Actual horizontal clearances shall be shown in the plan view of the Preliminary Plan (to the nearest 0.1 foot). Minimum horizontal clearances to inclined columns or wall surfaces should be provided at the roadway surface and for a vertical distance of 6 feet above the edge of pavement. When bridge end slopes fall within the recovery area, the minimum horizontal clearance should be provided for a vertical distance of 6 feet above the fill surface. See Figure 2.3.1-1.

Bridge piers and abutments ideally should be placed such that the minimum clearances can be satisfied. However, if for structural or economic reasons, the best span arrangement requires a pier to be within clear zone or recovery area, then guardrail or barrier can be used to mitigate the hazard.

There are instances where it may not be possible to provide the minimum horizontal clearance even with guardrail or barrier. An example would be placement of a bridge pier in a narrow median. The required column size may be such that it would infringe on the shoulder of the roadway. In such cases, the New Jersey barrier shape would be incorporated into the shape of the column. Barrier or guardrail would need to taper into the pier at a flare rate satisfying the criteria in Chapter 710 of the *Design Manual*. See Figure 2.3.1-2. The reduced clearance to the pier would need to be approved by the region.

D. Vertical Clearances

The required minimum vertical clearances are established by the functional classification of the highway and the construction classification of the project. For state highways, this is as outlined in Chapters 430 and 440 of the *Design Manual*. For city and county arterials, this is as outlined in Chapter IV of the Local Agency Guidelines.

Actual minimum vertical clearances are shown on the Preliminary Plan (to the nearest 0.1 foot). The approximate location of the minimum vertical clearance is noted in the upper left margin of the plan. For structures crossing divided highways, minimum vertical clearances for both directions are noted.

E. End Slopes

The type and rate of end slope used at bridge sites is dependent on several factors. Soil conditions and stability, right of way availability, fill height or depth of cut, roadway alignment and functional classification, and existing site conditions are all important.

The region should have made a preliminary determination based on these factors during the preparation of the bridge site data. The side slopes noted on the Roadway Section for the roadway should indicate the type and rate of end slope.

The Materials Lab will recommend the minimum rate of end slope. This should be compared to the rate recommended in the Roadway Section and to existing site conditions (if applicable). The types of end slopes and the conditions for which each are applicable are spelled out in Chapter 640 of the *Design Manual*.

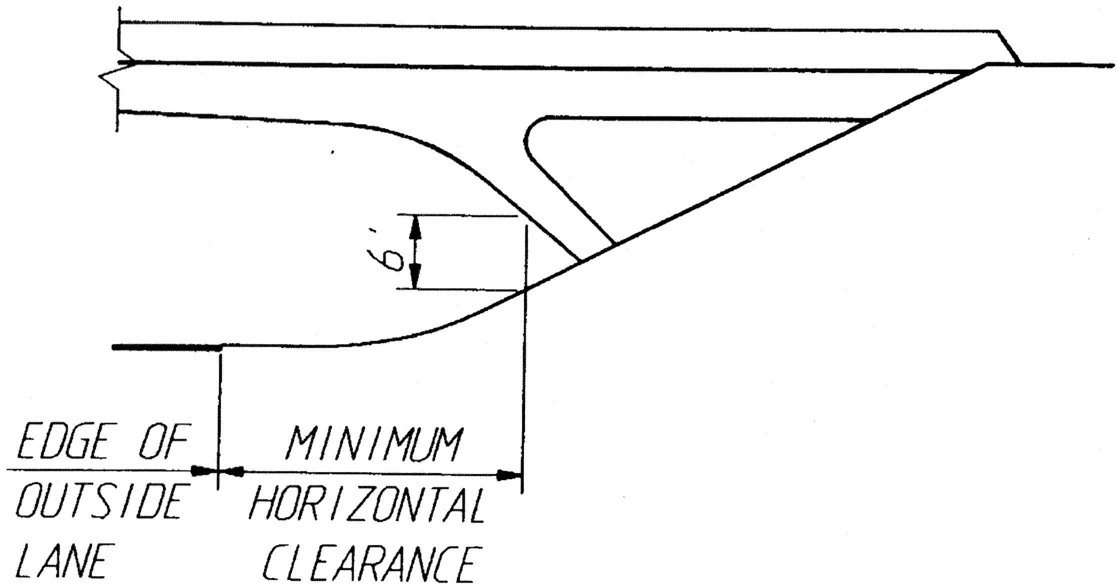
End slope protection may be required at certain highway crossings, as spelled out in Chapter 1120 of the *Design Manual*. Examples of slope protection are shown on Standard Plan D-9.

F. Determination of Bridge Length

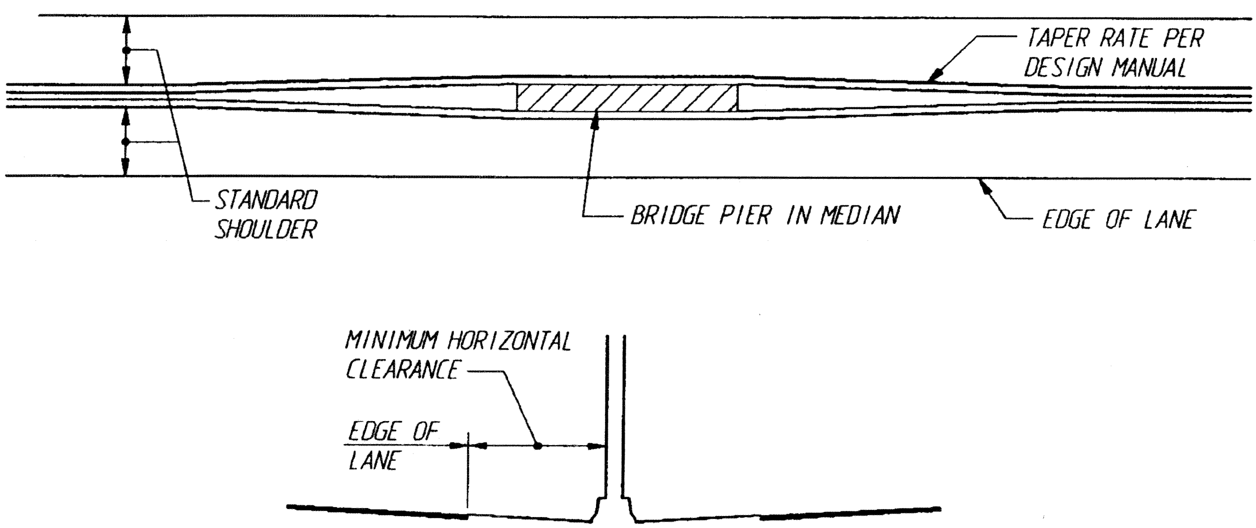
Establishing the location of the end piers for a highway crossing is a function of the profile grade of the overcrossing roadway, the minimum vertical and horizontal clearances required for the structure, and the type and rate of end slope used.

For the general case of bridges in cut or fill slopes, the control point is where the cut or fill slope plane meets the bottom of ditch or edge of shoulder as applicable. From this point, the fill or cut slope plane is established at the recommended rate up to where the slope plane intersects the grade of the roadway at the shoulder. Following the requirements of Standard Plan H-9, the back of pavement seat, end of wing wall or end of retaining wall can be established at 3 feet behind the slope intersection.

For the general case of bridges on wall type or "closed" abutments, the controlling factors are the required horizontal clearance and the size of the abutment. This situation would most likely occur in an urban setting or where right of way is limited.




Horizontal Clearance to Inclined Piers
1990
Figure 2.3.1-1




Bridge Pier in Narrow Median
1990
Figure 2.3.1-2

G. Pedestrian Crossings

Pedestrian crossings follow the same format as highway crossings. Geometric criteria for pedestrian facilities are established in Chapter 1020 of the *Design Manual.* Width and clearances would be as established there and as confirmed by region. Unique items to be addressed with pedestrian facilities include ADA requirements, the railing to be used, handrail requirements, overhead enclosure requirements, and profile grade requirements for ramps and stairs.

H. Bridge Redundancy

Design bridges to minimize the risk of catastrophic collapse by using redundant supporting elements (columns and girders).

For substructure design use:

One column minimum for roadways <u>40</u> feet wide and under.
Two columns minimum for roadways over <u>40</u> feet to <u>6</u>0 feet.
Three columns minimum for roadways over 60 feet.
Collision protection or design for collision loads for piers with one or two columns.

For superstructure design use:

Three girders (webs) minimum for roadways 32 feet and under.
Four girders (webs) minimum for roadways over 32 feet.

See Appendix 2.3-A2 for details.

Note: Any deviation from the above guidelines shall have a written approval by the Bridge Design Engineer.

## 2.3.2 Railroad Crossings

A. General

A railroad crossing is defined as a grade separation between an intersecting highway and a railroad. A bridge which provides highway traffic over the railroad is called an overcrossing. A bridge which provides highway traffic under the railroad is called an undercrossing.

Requirements for railroad separations for both undercrossings and overcrossings may involve negotiations with the railroad company concerning clearances, geometrics, utilities, and maintenance roads. The railroad's review and approval, will be based on the completed Preliminary Plan.

B. Criteria

The initial Preliminary Plan shall be prepared in accordance with the criteria of this section to apply uniformly to all railroads. Variance from this criteria will be negotiated with the railroad, when necessary, after a Preliminary Plan has been provided for their review.

C. Bridge Width

For railroad overcrossings, the provisions of Section 2.3.1 pertaining to bridge width of highway crossings shall apply. Details for railroad undercrossings will depend on the specific project and the railroad involved.

D. Horizontal Clearances

For railroad undercrossings, the provisions of Section 2.3.1 pertaining to horizontal clearances for highway crossings shall apply. However, because of the heavy live loading of railroad spans, it is advantageous to reduce the span lengths as much as possible. For railroad undercrossings skewed to the roadway, piers may be placed up to the outside edge of 8-foot (minimum) shoulders if certain conditions are met (structural requirements, satisfactory aesthetics, satisfactory sight distance, etc.).

The actual minimum horizontal clearances are shown in the Plan view of the Preliminary Plan (to the nearest 0.1 foot). For railroad overcrossings, minimum horizontal clearances are as noted below:

| | **Railroad Alone** |
|---|---|
| Fill Section | 14 feet |
| Cut Section | 16 feet |

Horizontal clearance shall be measured from the center of the outside track to the face of pier. When the track is on a curve, the minimum horizontal clearance shall be increased at the rate of $1^1/_2$ inches for each degree of curvature. An additional 8 feet of clearance for off-track equipment shall only be provided when specifically requested by the railroad.

E. Crash Walls

Crash walls, when required, shall be designed to conform to the criteria from of the *AREA Manual.*

F. Vertical Clearances

For railroad undercrossings, the provisions of Section 2.3.1 pertaining to vertical clearances of highway crossings shall apply. For railroad overcrossings, the minimum vertical clearance shall satisfy the requirements of Chapter 1120 of the *Design Manual.*

The actual minimum vertical clearances are shown on the Preliminary Plan (to the nearest 0.1 foot). The approximate location of the minimum vertical clearance is noted in the upper left margin of the plan.

G. Determination of Bridge Length

For railroad overcrossings, the provisions of Section 2.3.1 pertaining to the determination of bridge length shall apply. For railroad overcrossings, the minimum bridge length shall satisfy the minimum horizontal clearance requirements. The minimum bridge length shall generally satisfy the requirements of Figure 2.3.2-1.

H. Special Considerations

For railroad overcrossings, the top of footings for bridge piers or retaining walls adjacent to railroad tracks shall be 2 feet or more below the top of tie. The footing face shall not be closer than 10 feet to the center of the track. Any cofferdams, footings, excavation, etc., encroaching within 10 feet of the center of the track requires the approval of the railroad.

For railroads, the minimum horizontal construction opening is 8 feet 6 inches to either side of the centerline of track. The minimum vertical construction opening is 22 feet 6 inches above the top of rail at 6 feet offset from the centerline of track. Falsework openings shall be checked to verify that enough space is available for falsework beams to span the required horizontal distances and still provide the minimum vertical falsework clearance. Minimum vertical openings of less than 22 feet 6 inches may be negotiated with the railroad through the Utilities-Railroad Engineer.

### 2.3.3 Water Crossings

A. Bridge Width

The provisions of Section 2.3.1 pertaining to bridge width for highway crossings apply here.

B. Horizontal Clearances

Water crossings over navigable waters requiring clearance for navigation channels shall satisfy the horizontal clearances required by the Coast Guard. Communication with the Coast Guard will be handled through the Coast Guard Liaison Engineer. For bridges over navigable waters, the centerline of the navigation channel and the horizontal clearances (to the nearest 0.1 foot) to the piers or the pier protection are shown on the Plan view of the Preliminary Plan.

C. Vertical Clearances

Vertical clearances for water crossings must satisfy floodway clearance and, where applicable, navigation clearance.

Bridges over navigable waters must satisfy the vertical clearances required by the Coast Guard. Communication with the Coast Guard will be handled through the Coast Guard Liaison Engineer. The actual minimum vertical clearance (to the nearest 0.1 foot) for the channel span is shown on the Preliminary Plan. The approximate location of the minimum vertical clearance is noted in the upper left margin of the plan. The clearance shall be shown to the water surface as required by the Coast Guard criteria.

Floodway vertical clearance will need to be discussed with the Hydraulics Office. In accordance with the flood history, nature of the site, character of drift, and other factors, they will determine a minimum vertical clearance for the 100-year flood. The roadway profile and the bridge superstructure depth must accommodate this. The actual minimum vertical clearance to the 100-year flood is shown (to the nearest 0.1 foot) on the Preliminary Plan, and the approximate location of the minimum vertical clearance is noted in the upper left margin of the plan.

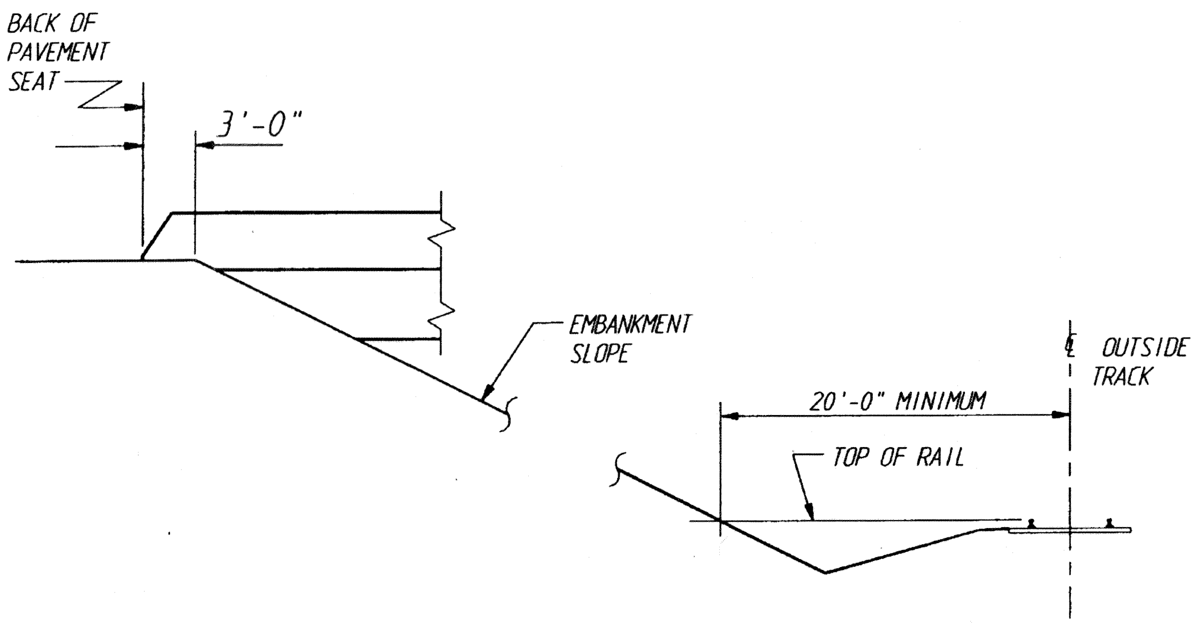
D. End Slopes

The type and rate of end slopes for water crossings is similar to that for highway crossings. Soil conditions and stability, fill height, location of toe of fill, existing channel conditions, flood and scour potential, and environmental concerns are all important.

As with highway crossings, the region, and Materials Lab will make preliminary recommendations as to the type and rate of end slope. The Hydraulics Office will also review the Regions's recommendation for slope protection.

E. Determination of Bridge Length

Determining the overall length of a water crossing is not as simple and straight forward as for a highway crossing. Floodway requirements and environmental factors have a significant impact on where piers and fill can be placed.




Determination of Bridge Length for a Railroad Undercrossing
Figure 2.3.2-1

If a water crossing is required to satisfy floodway and environmental concerns, it will be known by the time the Preliminary Plan has been started. Environmental studies and the Design Report prepared by the region will document any restrictions on fill placement, pier arrangement, and overall floodway clearance. The Hydraulics Office will need to review the size, shape, and alignment of all bridge piers in the floodway and the subsequent effect they will have on the base flood elevation. The overall bridge length may need to be increased depending on the span arrangement selected and the change in the flood backwater, or justification will need to be documented.

F. Scour

The Hydraulics Office will indicate the anticipated depth of scour at the bridge piers. They will recommend pier shapes to best streamline flow and reduce the scour forces. They will also recommend measures to protect the piers from scour activity or accumulation of drift (minimum cover to top of footing, riprap, pier alignment to stream flow, closure walls between pier columns, etc.).

G. Pier Protection

For bridges over navigable channels, piers adjacent to the channel may require pier protection. The Coast Guard will determine whether pier protection is required. This determination is based on the horizontal clearance provided for the navigation channel and the type of navigation traffic using the channel.

H. Construction Access and Time Restrictions

Water crossings will typically have some sort of construction restrictions associated with them. These must be considered during preliminary plan preparation.

The time period that the contractor will be allowed to do work within the waterway may be restricted by regulations administered by various agencies. Depending on the time limitations, a bridge with fewer piers or faster pier construction may be more advantageous even if more expensive.

Contractor access to the water may also be restricted. Shore areas supporting certain plant species are sometimes classified as wetlands. In order to work in or gain access through such areas, a work trestle may be necessary. Work trestles may also be necessary for bridge removal as well as new bridge construction.

### 2.3.4 Bridge Widenings

A. Bridge Width

The provisions of Section 2.3.1 pertaining to bridge width for highway crossings shall apply. In most cases, the width to be provided by the widening will be what is called for by the design standards, unless a deviation is approved.

B. Traffic Restrictions

Bridge widenings inherently involve traffic restrictions on the lanes above and where applicable on the lanes below. The bridge site data submitted by the district should contain information regarding temporary lane widths and staging configurations. This information should be checked to be certain that the existing bridge width, and the bridge roadway width during the intermediate construction stages of the bridge are sufficient for the lane widths, shy distances, temporary barriers, and construction room for the contractor. These temporary lane widths and shy distances are noted on the Preliminary Plan. The temporary lane widths and shy distances on the roadway beneath the bridge being widened should also be checked that adequate clearance is available for any substructure construction.

C. Construction Sequence

Using the traffic restriction data in the bridge site data, a construction sequence shall be developed. Such a sequence shall take into account necessary steps for construction of the bridge widening (substructure and superstructure), any construction work off of and adjacent to the structure, and the requirements of traffic flow on and below the structure. Checks shall be made to be certain that girder spacings, closure pours, and removal work are all compatible with the traffic arrangements.

Projects with several bridges being widened at the same time should have sequencing that is compatible with the region's traffic plans during construction and that allow the contractor room to work. It is important to meet with the region project staff to assure that the construction staging and characterization of traffic during construction is constructible and minimizes the impact to the traveling public.

### 2.3.5 Detour Structures

A. Bridge Width

The lane widths, shy distances, and overall roadway widths for detour structures are determined by the Region. Review and approval of detour roadway widths is done by the Traffic Office.

B. Live Load

Unless otherwise justified, all detour structures shall be designed for an AASHTO HS 15 live load. Construction requirements and staging can be sufficient reason to justify designing for a higher live load.

### 2.3.6 Retaining Walls and Noise Walls

The requirements for Preliminary Plans for retaining walls and noise walls are similar to the requirements for bridges. The plan and elevation views define the overall limits and the geometry of the wall. The section view will show general structural elements that are part of the wall and the surface finish of the wall face.

The most common types of walls are outlined in Section 9.4.2 of the *Bridge Design Manual* and Chapter 1130 of the *Design Manual.* The Bridge and Structures Office is responsible for Preliminary Plans for all nonstandard walls (retaining walls and noise walls) as spelled out in Chapter 1130 of the *Design Manual.*

### 2.3.7 Bridge Deck Drainage

The Hydraulics Office provides a review of the Preliminary Plan with respect to the requirements for bridge deck drainage. As soon as the Preliminary Plan has been developed to the point that the length and width of the structure, profile grade, and superelevation diagram are shown on the plan, a reduced print shall be provided to the Hydraulics Office for their review. Any other pertinent information (such as locations of drainage off the structure) should be given to them also. For work with existing structures, the locations of any and all bridge drains shall be noted.

The Hydraulics Office will determine the type of drains necessary (if any) and their location and spacing requirements. They will furnish any details or modifications required for special drains or special situations.

If low points of sag vertical curves or superelevation crossovers occur within the limits of the bridge, the region should be asked to revise their geometrics to place these features outside the limits of the bridge. If such revisions cannot be made, the Hydraulics Office will provide details to handle drainage with bridge drains on the structure.

### 2.3.8 Bridge Deck Protective Systems

The Preliminary Plan shall note in the lower left margin the type of deck protective system to be utilized on the bridge. The most commonly used systems are described in Section 8.4.7 of the *Bridge Design Manual.*

New construction will generally be System 1 ($2^1/_2$-inch concrete cover plus epoxy-coated rebars). System 2 (MC overlay) and System 3 (ACP overlay) are to be used on new construction that require overlays and on widenings for major structures. The type of overlay to be used should be noted in the bridge site data submitted by the region. The bridge condition report will indicate the preference of the Bridge and Structures Office and the Deck Systems Specialist in the Bridge and Structures Office.

### 2.3.9 Construction Clearances

Most projects will involve construction in and around traffic. Both traffic and construction have to be accommodated. Construction clearances and working room must be reviewed at the Preliminary Plan stage to verify the constructibility of the project.

For construction clearances for roadways, the region shall supply the necessary traffic staging information with the bridge site data. This includes temporary lane widths and shy distances, allowable or necessary alignment shifts, and any special minimum vertical clearances. With this information, the designer can establish the falsework opening or construction opening.

The horizontal dimension of the falsework or construction opening shall be the sum of the temporary traffic lane widths and shy distances, plus two 2-foot temporary concrete barriers, plus 2 feet shy behind these barriers. For multispan openings, a minimum of 2 feet shall be assumed for the interior support. This interior support shall also have 2 feet shy on both sides to the two 2-foot temporary concrete barriers that will flank it.

The vertical clearance shall normally be 14 feet 6 inches minimum. The space available for the falsework must be enough for whatever depth is necessary to span the required horizontal opening. If the necessary depth is greater than the space available, either the minimum vertical clearance for the falsework shall be reduced or the horizontal clearance and span for the falsework shall be reduced.

Preferably, the falsework span shall not exceed 38 feet. This limits the stresses in the new structure from the construction and concrete pouring sequences. While the falsework or construction openings are measured normal to the crossroad alignment, the falsework span is measured parallel to the bridge alignment.

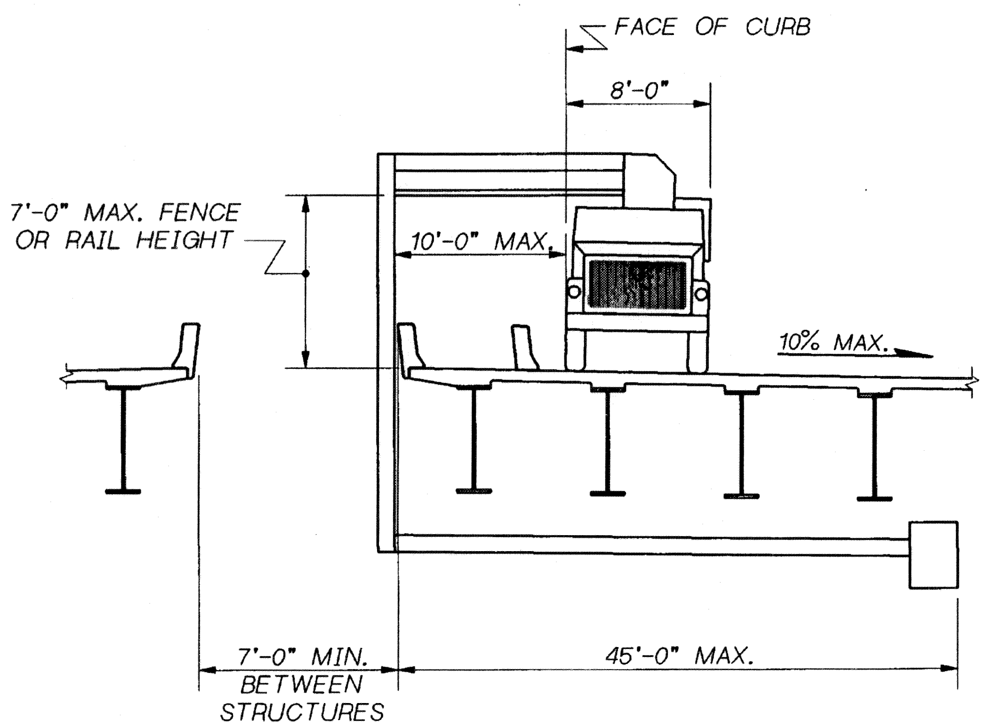
Once the construction clearances have been determined the designer should meet with the region to review the construction clearances to assure compatibility with the construction staging. This review should take place prior to finalization of the preliminary bridge plan.

For railroads see Section 2.3.2H.

## 2.3.10 Inspection and Maintenance Access

A. General

Bridge inspection is required by the FHWA a minimum of every two years. The inspectors are required to access the bridge components to within 3 feet (1 meter). Maintenance forces need to access damaged members and locations that may collect debris. This is accomplished by using many methods. Safety cables, ladders, bucket trucks, Under Bridge Inspection Truck (UBIT), (see Figure 2.3.10-1), and under bridge travelers are just a few of the most common methods. Preliminary designers need to be aware of these requirements to assist the inspectors efforts over the life of the bridge. Access should be considered throughout the Preliminary Plan TS&L stages.




LIMITS OF UNDER BRIDGE INSPECTION TRUCK

UBITS CAN ONLY DEPLOY TO THE RIGHT SIDE OF TRUCK

Figure 2.3.10-1

B. Safety Cables

Safety cables strung on steel plate girders or trusses allow for walking access. Care must be given to the application and location. Built-up plate girder bridges are detailed with a safety cable for inspectors walking the bottom flange. However, when the girders become more than 8 feet deep, the inspection of the top flange and top lateral connections becomes difficult. When the girders are less than 5 feet deep, it is not feasible for the inspectors to stand on the bottom flanges. On large trusses, large gusset plates (3 feet or more wide) are difficult to negotiate around. Cable are best run on the exterior of the bridge except at large gusset plates. At these locations, cables or lanyard anchors should be placed on the inside face of the truss. This way inspectors can utilize bottom lateral gusset plates to stand on while traversing around the main truss gusset.

C. Travelers

Under bridge travelers, placed on rails that remain permanently on the bridge, can be considered on large steel structures. This is an expensive option but it should be evaluated for large bridges with high ADT as access to the bridge would be limited by traffic windows that specify when a lane can be closed. Some bridges are restricted to weekend UBIT inspection for this reason.

*4:P:BDM2*

## 2.4 Selection of Structure Type

### 2.4.1 Bridge Types

The following superstructure depth to span ratios have been determined from past experience to be reasonable and economical and are in some cases less than the minimum depth recommended by AASHTO. In this situation, the *Bridge Design Manual* will govern. The length of span used to determine superstructure depth shall be the length between centerline of bearings. Do not use the length between points of dead load contraflexure as noted in AASHTO for design.

A. Reinforced Concrete Slab

1. Use

   Used for simple and continuous spans up to 60 feet.

2. Characteristics

   Design details and falsework relatively simple. Shortest construction time for any cast-in-place structure. Correction for anticipated falsework settlement must be included in the dead load camber curve because of the single concrete pour.

3. Depth/Span Ratios

   a. Constant depth

   | | |
   |---|---|
   | Simple spans | 1/22 |
   | Continuous spans | 1/25 |

   b. Variable depth

   Adjust ratios to account for change in relative stiffness of positive and negative moment sections.

B. Reinforced Concrete Tee-Beam

1. Use

   Used for continuous spans 30 feet to 60 feet. Has been used for longer spans with inclined leg piers.

2. Characteristics

   Forming and falsework is more complicated than flat slab. Construction time is longer than for a flat slab.

3. Depth/Span Ratios

   a. Constant depth

   | | |
   |---|---|
   | Simple spans | 1/13 |
   | Continuous spans | 1/15 |

   b. Variable depth

   Adjust ratios to account for change in relative stiffness of positive and negative moment sections.

C. Reinforced Concrete Box Girder

1. Use

Used for continuous spans 50 feet to 130 feet. Maximum simple span 110 feet to limit excessive dead load deflections.

2. Characteristics

Forming and falsework is somewhat complicated. Construction time is approximately the same as for a tee-beam. High torsional resistance makes it desirable for curved alignments.

3. Depth/Span Ratios*

a. Constant depth

| | |
|---|---|
| Simple spans | 1/18 |
| Continuous spans | 1/20 |

b. Variable depth

Adjust ratios to account for change in relative stiffness of positive and negative moment sections.

*If the configuration of the exterior web is sloped and curved, a larger depth/span ratio may be necessary.

D. Post-Tensioned Concrete Box Girder

1. Use

Normally used for continuous spans longer than 130 feet or simple spans longer than 110 feet. Should be considered for shorter spans if a shallower structure depth is needed.

2. Characteristics

Construction time is somewhat longer due to post-tensioning operations. High torsional resistance makes it desirable for curved alignments.

3. Depth/Span Ratios*

a. Constant depth

| | |
|---|---|
| Simple spans | 1/20.5 |
| Continuous spans | 1/25 |

b. Variable depth

| | |
|---|---|
| Two span structures | |
| @ Center of span | 1/25 |
| @ Intermediate pier | 1/12.5 |
| Multispan structures | |
| @ Center of span | 1/36 |
| @ Intermediate pier | 1/18 |

*If the configuration of the exterior web is sloped and curved, a larger depth/span ratio may be necessary.

E. Prestressed Concrete Sections

1. Use

Local precast fabricators have several standard forms available for precast concrete sections based on WSDOT standard girder series. They are versatile enough to cover a wide variety of span lengths.

WSDOT standard girders are:

a. W95G, W836, WF74G, W74G, W58G, W50G, and W42G prestressed, concrete I-girders requiring a cast-in-place concrete roadway deck used for spans less than 180 feet.

b. Precast trapezoidal (TUB) girder requiring a cast–in–place concrete roadway deck, used for spans less than 140 ft.

c. W53DG, W41DG and W35DG prestressed, concrete decked bulb tee girders requiring an ACP overlay roadway surface used for span less than 150 ft.

d. 12-inch, 18-inch, and 26-inch precast prestressed slabs requiring an ACP overlay roadway surface used for spans less than 80 ft.

e. 26-inch precast prestressed tribeam requiring an ACP overlay roadway surface used for span less than 40 ft.

2. Characteristics

Construction details and forming are fairly simple. Construction time is less than for a cast-in-place bridge. Little or no falsework is required.

F. Post Tensioned Precast Spliced Girders

1. Use

For long span prestressed girder using standard forms for precast concrete sections based on WSDOT Standard Girder Series.

a. W95PTG, W83PTG and WF74PTG post tensioned precast I–girders with cast–in–place concrete roadway deck use for simple span up to 250 ft. and continuous span up to 250 ft.

b. Post tensioned precast tub girders with cast–in–place concrete roadway deck used for simple span up to 200 ft. and continuous span up to 250 ft.

G. Composite Steel Plate Girder

1. Use

For simple spans up to 260 feet and for continuous spans from 120 to 400 feet. Relatively low dead load when compared to a concrete superstructure makes this bridge type an asset in areas where foundation materials are poor.

2. Characteristics

Construction details and forming are fairly simple Construction time is comparatively short. Shipping and erecting of large sections must be reviewed. Cost of maintenance is higher than for concrete bridges. Current cost information should be considered because of changing steel market conditions.

3. Depth/Span Ratios

   a. Constant depth

| | |
|---|---|
| Simple spans | 1/22 |
| Continuous spans | 1/25 |

   b. Variable depth

| | |
|---|---|
| @ Center of span | 1/40 |
| @ Intermediate pier | 1/20 |

H. Composite Steel Box Girder

1. Use

   For simple spans up to 260 feet and for continuous spans from 120 to 400 feet. Relatively low dead load when compared to a concrete superstructure makes this bridge type an asset in areas where foundation materials are poor.

2. Characteristics

   Construction details and forming are more difficult than for a steel plate girder. Shipping and erecting of large sections must be reviewed. Current cost information should be considered because of changing steel market conditions.

3. Depth/Span Ratios

   a. Constant depth

| | |
|---|---|
| Simple spans | 1/22 |
| Continuous spans | 1/25 |

   b. Variable depth

| | |
|---|---|
| @ Center of span | 1/40 |
| @ Intermediate pier | 1/20 |

   Sloping webs are not used on box girders of variable depth.

I. Steel Truss

1. Use

   For simple spans up to 300 feet and for continuous spans up to 1,200 feet. Used where vertical clearance requirements dictate a shallow superstructure and long spans or where terrain dictates long spans and construction by cantilever method.

2. Characteristics

   Construction details are numerous and can be complex. Cantilever construction method can facilitate construction over inaccessible areas. Through trusses are discouraged because of the resulting restricted horizontal and vertical clearances for the roadway.

3. Depth/Span Ratios

   a. Simple spans 1/6
   b. Continuous spans

| | |
|---|---|
| @ Center of span | 1/18 |
| @ Intermediate pier | 1/9 |

J. Segmental Concrete Box Girder

1. Use

For continuous spans from 200 to 700 feet. Used where site dictates long spans and construction by cantilever method.

2. Characteristics

Use of travelers for the form apparatus facilitates the cantilever construction method enabling long-span construction without falsework. Precast concrete segments may be used. Tight geometric control is required during construction to ensure proper alignment.

3. Depth/Span Ratios

Variable depth

| | |
|---|---|
| @ Center of span | 1/50 |
| @ Intermediate pier | 1/20 |

K. Railroad Bridges

1. Use

For railroad undercrossings, most railroad companies prefer simple span steel construction. This is to simplify repair and reconstruction in the event of derailment or some other damage to the structure.

2. Characteristics

The heavier loads of the railroad live load require deeper and stiffer members than for highway bridges. Through girders can be used to reduce overall structure depth if the railroad concurs. Piers should be normal to the railroad to eliminate skew loading effects.

3. Depth/Span Ratios

Constant depth

| | |
|---|---|
| Simple spans | 1/12 |
| Continuous two span | 1/14 |
| Continuous multi-span | 1/15 |

L. Timber

1. Use

Generally used for spans under 40 feet. Usually used for detour bridges and other temporary structures.

2. Characteristics

Excellent for short-term duration as for a detour. Simple design and details.

3. Depth/Span Ratios

Constant depth

| | |
|---|---|
| Simple span – Timber beam | 1/10 |
| Simple span – Glulam beam | 1/12 |
| Continuous spans | 1/14 |

M. Other

Bridge types such as cable-stayed, suspension, arch, tied arch, and floating bridges have special and limited applications. Their use is generally dictated by site conditions. Preliminary design studies will generally be done when these types of structures are considered.

### 2.4.2 Wall Types

The process of selecting a type of retaining wall should economically satisfy structural, functional, and aesthetic requirements and other considerations relevant to a specific site. A detailed listing of the common wall types and their characteristics can be found in Section 9.4.2 of the *Bridge Design Manual.*

2:-4DTP:BDM2

## 2.5 Aesthetic Considerations

### 2.5.1 General Visual Impact

A bridge can be a strong feature in any landscape. Steps must be taken to assure that even the most basic structure will complement rather than detract from its surroundings. The Design Report, EIS, and bridge site data submitted by the region should each contain a discussion on the aesthetic importance of the project site. This commentary, along with the video and/or pictures submitted, will help the designer determine the appropriate structure. Generally a visit to the bridge site with the Bridge Architect and the region will be made as well. The Bridge Architect should be contacted early in the preliminary bridge plan process for input.

Aesthetics is a very subjective element that must be factored into the design process in the otherwise very quantitative field of structural engineering. Bridges that are well proportioned structurally using the least material possible are generally well proportioned. However, the details such as pier walls, columns, and crossbeams require special attention to ensure a structure that will enhance the general vicinity.

### 2.5.2 End Piers

A. Wing Walls

The size and exposure of the wing wall at the end pier should balance, visually, with the depth and type of superstructure used. For example, a prestressed girder structure fits best visually with a 15-foot wing wall (or curtain wall/retaining wall). However, there are instances where a 20-foot wing wall (or curtain wall/retaining wall) may be used with a prestressed girder (maximizing a span in a remote area, for example). These guidelines shall be used with engineering judgment and with the review of the Bridge Architect.

It is less expensive for bridges of greater than 40 feet of overall width to be designed with wing walls (or curtain wall/retaining wall) than to use a longer superstructure.

B. Retaining Walls

For structures at sites where profile, right of way, and alignment dictate the use of high exposed wall-type abutments for the end piers, retaining walls that flank the approach roadway can be used to retain the roadway fill and reduce the overall structure length. Stepped walls are often used to break up the height, and allow for landscape planting. A curtain wall runs between the bridge abutment and the heel of the abutment footing. In this way, the joint in the retaining wall stem can coincide with the joint between the abutment footing and the retaining wall footing. This simplifies design and provides a convenient breaking point between design responsibilities if the retaining walls happen to be the responsibility of the region. The length shown for the curtain wall dimension is an estimated dimension based on experience and preliminary foundation assumptions. It can be revised under design to satisfy the intent of having the wall joint coincide with the end of the abutment footing.

C. Slope Protection

The region is responsible for making initial recommendations regarding slope protection. It should be compatible with the site and should match what has been used at other bridges in the vicinity. The type selected shall be shown on the Preliminary Plan. It shall be noted on the "Not Included in Bridge Quantities" list.

### 2.5.3 Intermediate Piers

The size, shape, and spacing of the intermediate pier elements must satisfy two criteria. They must be correctly sized and detailed to efficiently handle the structural loads required by the design and shaped to enhance the aesthetics of the structure.

The primary view of the pier must be considered. For structures that cross over another roadway, the primary view will be a section normal to the roadway. This may not always be the same view as shown on the Preliminary Plan as with a skewed structure, for example. This primary view should be the focus of the aesthetic review.

Tapers and flairs on columns should be kept simple and structurally functional. Fabrication and constructibility of the formwork of the pier must be kept in mind. Crossbeam ends should be carefully reviewed. Skewed bridges and bridges with steep profile grades or those in sharp vertical curves will require special attention to detail.

Column spacing should not be so small as to create a cluttered look. Column spacing should be proportioned to maintain a reasonable crossbeam span balance.

### 2.5.4 Barrier and Wall Surface Treatments

A. Plain Surface Finish

This finish will normally be used on structures that do not have a high degree of visibility or where existing conditions warrant. A bridge in a remote area or a bridge among several existing bridges all having a plain finish would be examples.

B. Fractured Fin Finish

This finish is the most common and an easy way to add a decorative texture to a structure. Variations on this type of finish can be used for special cases. The specific areas to receive this finish should be reviewed with the Bridge Architect.

C. Pigmented Sealer

The use of a pigmented sealer can also be an aesthetic enhancement. The particular hue can be selected to blend with the surrounding terrain. Most commonly, this would be considered in urban areas. The selection should be reviewed with the Bridge Architect and the region.

### 2.5.5 Superstructure

The horizontal elements of the bridge are perhaps the strongest features. The sizing of the structure depth based on the span/depth ratios in Section 2.4.1, will generally produce a balanced relationship.

Haunches or rounding of girders at the piers can enhance the structure's appearance. The use of such features should be kept within reason considering fabrication of materials and construction of formwork. The amount of haunch should be carefully reviewed for overall balance from the primary viewing perspective.

The slab overhang dimension should approach that used for the structure depth. This dimension should be balanced between what looks good for aesthetics and what is possible with a reasonable slab thickness and reinforcement.

For box girders, the exterior webs can be sloped. The amount of slope should not exceed $1^1/_2$: 1 for structural reasons. Sloped webs should only be used in locations of high aesthetic impact.

## 2.6 Miscellaneous

### 2.6.1 Structure Costs

Historical bridge and structure cost data is outlined in Chapter 12. When using this data for cost estimates, the cost range assumed shall be based on the amount of information available. Unless foundation conditions are known, the worst case conditions would be assumed (e.g., pile foundations) for cost analysis. An estimate contingency of 10 percent (minimum) staff be added to all preliminary bridge plan estimates. For small projects or remote areas, high-range costs would be used. The cost data would be adjusted for inflation to the current date. Estimates include mobilization but not sales tax, engineering, future inflation, or contingencies, and the accuracy of the estimate is ±15 percent.

### 2.6.2 Handling and Shipping Precast Members and Steel Beams

Bridges utilizing precast concrete beams or steel beams need to have their access routes checked and sites reviewed to be certain that the beams can be transported to the site. It must also be determined that they can be erected once they reach the site.

Both the size and the weight of the beams must be checked. Likely routes to the site must be adequate to handle the truck and trailer hauling the beams. Avoid narrow roads with sharp turns, steep grades, and/or load-rated bridges which may prevent the beams from reaching the site. The Condition Survey Section of the Bridge and Structures Office should be consulted for limitations on hauling lengths and weights.

The site should be reviewed for adequate space for the contractor to set up the cranes and equipment necessary to pick up and place the girders. The reach and boom angle should be checked and should accommodate standard cranes.

### 2.6.3 Salvage of Materials

When a bridge is being replaced or widened, the material being removed should be reviewed for anything that WSDOT may want to salvage. Items such as aluminum rail, luminaire poles, sign structures, and steel beams should be identified for possible salvage. The region should be asked if such items are to be salvaged since they will be responsible for storage and inventory of these items.

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## 2.7 WSDOT Standard Highway Bridge

### 2.7.1 Design Elements

The following are standard design elements for highway undercrossings and overcrossings. They are meant to provide a generic base for consistent, clean looking bridges, and to reduce design and construction costs. Modification of some elements may be required, depending on site conditions. This should be determined on a case-by-case basis during the preliminary plan stage of the design process.

A. General

Fractured Fin Finish shall be used on the exterior face of the traffic barrier. All other surfaces shall be Plain Surface Finish.

Exposed faces of wingwalls, columns, and abutments shall be vertical. The exterior face of the traffic barrier and the end of the intermediate pier crossbeam and diaphram shall have a 1:12 backslope.

B. Substructure

End piers use the following details:

15′-0″ wingwalls or 20′-0″

Stub abutment wall with vertical face. Footing elevation, pile type (if required), and setback dimension are determined from recommendations in the WSDOT Materials Laboratory Foundation Report.

Intermediate piers use the following details:

"Semi-raised" Crossbeams: The crossbeam below the girders is designed for the girder and slab dead load, and construction loads. The crossbeam and the diaphram together are designed for all live loads and composite dead loads. The crossbeam shall be 3′-0″ minimum depth.

"Raised" Crossbeams: The crossbeam is at the same level as the girders is designed for all deadand live loads. "Raised" of crossbeams are only used in conjunction with Trapezoidal Tub Girgers.

Round Columns: Columns shall be 3′-0″ or 4′-0″ in diameter. Dimensions are constant full height with no tapers. Bridges with roadway widths of 40′ or less will generally be single column piers. Bridges with roadway widths of greater the 40′ shall have two or more columns, following the criteria established in Section 2.3.1 H.

C. Superstructure

Concrete Slab: 7 ½″ minimum thickness, with the top mat being epoxy coated steel reinforcing bars.

Prestressed Girders: Girder spacing will vary depending on roadway width and span length. The slab overhang dimension is approximately half of the girder spacing. Girder spacings typically range between 6′-0″ and 12′-0″.

| | |
|---|---|
| W95G | Spans up to about 170 feet |
| W83G | Spans up to about 180 feet |
| WF74G | Spans up to about 155 feet |
| WF74G | Spans up to about 145 feet |
| W58G | Spans up to about 120 feet |
| W50 | Spans up to about 100 feet |
| W42 | Spans up to about 80 feet |

Intermediate Diaphrams: Locate at the midspan for girders up to 80′ long. Locate at third points for girders over 80′ and 150′ long and at forth point over 150 ft.

End Diaphrams: "End Wall on Girder" type.

Traffic Barrier: New Jersey face barrier.

Fix Diaphrams: Full width of crossbeam between giders.

Hinge Diaphram: Full width of crossbeam between girders and outside of the exterior girders.

BP Rail: 3′-6″ overall height for pedestrian traffic. 4′-6″ overall height for bicycle traffic.

Sidewalk: 6″ height at curb line. Transverse slope of -.01′ per foot towards the curb line.

Sidewalk barrier: Inside face is vertical. Outside face slopes 1:12 outward.

D. Examples

Appendices 2.7-A1 and A2 detail the standard design elements of a standard highway bridge.

The following bridges are good examples of a standard highway bridge. However, they do have some modifications to the standard.

| | |
|---|---|
| SR 17 Undercrossing 395/110 | Contract 3785 |
| Mullenix Road Overcrossing 16/203E&W | Contract 4143 |

## 2.99 Bibliography

1. Federal Highway Administration (FHWA) publication *Federal Aid Highway Program Manual.*

   FHWA Order 5520.1 (dated December 24, 1990) contains the criteria pertaining to Type, Size, and Location studies.

   Volume 6, Chapter 6, Section 2, Subsection 1, Attachment 1 (Transmittal 425) contains the criteria pertaining to railroad undercrossings and overcrossings.

2. Washington Utilities and Transportation Commission *Clearance Rules and Regulations Governing Common Carrier Railroads.*

3. American Railway Engineering Association (AREA) *Manual for Railroad Engineering.* Note: This is the criteria which we follow except as superseded by FHWA or WSDOT criteria. This manual is used as the basic design and geometric criteria by all railroads.

4. Washington State Department of Transportation (WSDOT) *Design Manual* (M 22-01).

5. *Local Agency Guidelines* (M 36-63).

6. American Association of State Highway and Transportation Officials (AASHTO) *Standard Specifications for Highway Bridges.*

*DTP:BDM2*

Washington State Department of Transportation

# Bridge Site Data General

| Region | Made By | Date |
|---|---|---|
| | | |

## Bridge Information

| SR | Bridge Name | Control Section | Project No. |
|---|---|---|---|
| | | | |

| Highway Section | Section, Township & Range | Datum |
|---|---|---|
| | | |

Structure width between curbs ?

Will the structure be widened in a contract subsequent to this contract ? ☐ Yes ☐ No ☐ N/A

Which side and amount ?

Will the roadway under the structure be widened in the future? ☐ Yes ☐ No ☐ N/A

Stage construction requirements ? ☐ Yes ☐ No ☐ N/A

Should the additional clearance for off-track railroad maintenance equipment be provided?

Can a pier be placed in the median? ☐ Yes ☐ No ☐ N/A

What are the required falsework or construction opening dimensions ?

Are there detour or shoofly bridge requirements? (If Yes, attach drawings) ☐ Yes ☐ No ☐ N/A

Can the R/W be adjusted to accommodate toe of approach fills? ☐ Yes ☐ No ☐ N/A

What is the required vertical clearance?

What is the available depth for superstructure?

Are overlays planned for a contract subsequent to this contract ? ☐ Yes ☐ No ☐ N/A

Can profile be revised to provide greater or less clearance? ☐ Yes ☐ No ☐ N/A

If Yes, which line and how much?

Will bridge be contracted before, with or after approach fill? ☐ Before ☐ With ☐ After ☐ N/A

What are expected foundation conditions?

When can foundation drilling be accomplished?

Is slope protection or riprap required for the bridge end slopes? ☐ Yes ☐ No ☐ N/A

Are sidewalks to be provided? ☐ Yes ☐ No ☐ N/A

If Yes, which side and width?

Will sidewalks carry bicycle traffic? ☐ Yes ☐ No ☐ N/A

Will signs or illumination be attached to the structure? ☐ Yes ☐ No ☐ N/A

Will utility conduits be incorporated in the bridge? ☐ Yes ☐ No ☐ N/A

What do the bridge barriers transition to?

Furnish type and location of existing features within the limits of this project, such as retaining walls, sign support structures, utilities, buildings, powerlines, etc.

Any other data relative to selection of type, including your recommendations?

## Attachments

- ☐ Vicinity Map
- ☐ Bridge Site Contour Map
- ☐ Specific Roadway sections at bridge site and approved roadway sections
- ☐ Vertical Profile Data
- ☐ Horizontal Curve Data
- ☐ Superelevation Transition Diagrams
- ☐ Tabulated field surveyed and measured stations, offsets, and elevations of existing roadways
- ☐ Photographs and video tape of structure site, adjacent existing structures and surrounding terrain
- ☐
- ☐

DOT Form 235-002 EF
Revised 6/97

**Washington State Department of Transportation**

# Bridge Site Data Rehabilitation

| Region | Made By | Date |
|---|---|---|
| | | |

## Bridge Information

| SR | Bridge Name | Control Section | Project No. |
|---|---|---|---|
| | | | |

| Highway Section | Section, Township & Range | Datum |
|---|---|---|
| | | |

Existing roadway width, curb to curb ________ Left of ℄ ________ Right of ℄ ________

Proposed roadway width, curb to curb ________ Left of ℄ ________ Right of ℄ ________

Existing wearing surface *(concrete, ACP, ACP w /membrane, LMC, epoxy, other)* ________ Thickness ________

Existing drains to be plugged, modified, moved, other? ________

Proposed overlay *(ACP, ACP w /membrame, LMC, epoxy)* ________ Thickness ________

Is bridge rail to be modified? ☐ Yes ☐ No

Existing rail type ________

Proposed rail replacement type ________

Will terminal design "F" be required? ☐ Yes ☐ No

Will utilities be placed in the new barrier? ☐ Yes ☐ No

Will the structure be overlayed with or after rail replacement? ☐ With Rail Replacement ☐ After Rail Replacement

Condition of existing joints ________

Existing joints watertight? ☐ Yes ☐ No

Measure width of existing joint, normal to skew. @ curb line ________ Inch @ ℄ roadway ________ Inch @ curb line ________ Inch

Estimate structure temperature at time of joint measurement

Type of existing joint ________

Describe damage, if any, to existing joints ________

Existing Vertical Clearance ________

Proposed Vertical Clearance (at curb lines of traffic barrier) ________

## Attachments

☐ Video tape of project

☐ Sketch indicating points at which joint width was measured.

☐ Photographs of existing joints.

☐ Existing deck chloride and detamination data.

☐ Roadway deck elevations at curb lines (10-foot spacing)

DOT Form 235-002A EF
Revised 3/97

**Washington State Department of Transportation**

# Bridge Site Data Stream Crossings

| Region | Made By | Date |
|---|---|---|
| | | |

## Bridge Information

| SR | Bridge Name | Control Section | Project No. |
|---|---|---|---|
| | | | |

| Highway Section | Section, Township & Range | Datum |
|---|---|---|
| | | |

| Name of Stream | Tributary of |
|---|---|
| | |

Elevation of W.S. *(@ date of survey)* ________ Stream Velocity *(fps @ date of survey)* ________ Depth of Flow *(@ date of survey)* ________

Max Highwater Elevation ________ @ Date ________

Normal Highwater Elevation ________ @ Date ________

Normal Stage Elevation ________ @ Date ________

Extreme Low Water Elevation ________ @ Date ________

Amount and Character of Drift ________

Streambed Material ________

Datum *(i.e., USC and GS, USGS, etc.)* ________

Manning's "N" Value *(Est.)* ________

## Attachments

- ☐ Site Contour Map *(See Sect. 7.02.00 Highway Hydraulic Manual)*
- ☐ Highway Alignment and Profile *(refer to map and profiles)*
- ☐ Streambed: Profile and Cross Sections *(500 ft. upstream and downstream)*
- ☐ Photographs
- ☐ Character of Stream Banks *(i.e., rock, silt, etc.)* / Location of Solid Rock
- ☐ Other Data Relative to Selection of Type and Design of Bridge, Including your Recommendations *(i.e., requirements of riprap, permission of piers in channel, etc.)*

DOT Form 235-001 EF
Revised 3/97

Project__________________ SR______ Prelim. Plan by _____ Check by _____ Date_____

PRELIMINARY PLAN CHECKLIST

PLAN

___Survey Lines and Station Ticks
___Survey Line Intersection Angles
___Survey Line Intersection Stations
___Survey Line Bearings
___Roadway and Median Widths
___Lane and Shoulder Widths
___Sidewalk Width
___Connection/Widening for Guardrail/Barrier
___Profile Grade and Pivot Point
___Roadway Superelevation Rate (if constant)
___Lane Taper and Channelization Data
___Traffic Arrows
___Mileage to Junctions along Mainline
___Back to Back of Pavement Seats
___Span Lengths
___Lengths of Walls next to/ part of Bridge
___Pier Skew Angle
___Bridge Drains, or Inlets off Bridge
___Existing drainage structures
___Existing utilities Type/Size, and Location
___New utilities - Type, Size, and Location
___Luminaires, Junction Boxes, Conduits
___Bridge mounted Signs and Supports
___Contours
___Top of Cut: Toe of Fill
___Bottom of Ditches
___Test Holes (if available)
___Riprap Limits
___Stream Flow Arrow
___R/W Lines and/or Easement Lines
___Points of Minimum Vertical Clearance
___Horizontal Clearance
___Exist. Bridge No. (to be removed, widened)
___Section, Township, Range
___City or Town
___North Arrow
___SR Number
___Bearing of Piers, or note if radial

MISCELLANEOUS

___Structure Type
___Live Loading
___Undercrossing Alignment Profiles/Elevs.
___Superelevation Diagrams
___Curve Data
___Riprap Detail
___Layout Approval Block
___Notes to Region
___Names and Signatures
___Not Included in Bridge Quantities List
___Inspection and Maintenance Access

ELEVATION

___Full Length Reference Elevation Line
___Existing Ground Line x ft. Rt of Survey Line
___End Slope Rate
___Slope Protection
___Pier Stations and Grade Elevations
___Profile Grade Vertical Curves
___BP/Pedestrian Rail
___Barrier/Wall Face Treatment
___Construction/Falsework Openings
___Minimum Vertical Clearances
___Water Surface Elevations and Flow Data
___Riprap
___Seal Vent Elevation
___Datum
___Grade elevations shown are equal to ...
___For Embankment details at bridge ends ...
___Indicate F, H, or E at abutments and piers

TYPICAL SECTION

___Bridge Roadway Width
___Lane and Shoulder Widths
___Profile Grade and Pivot Point
___Superelevation Rate
___Survey Line
___Overlay Type and Depth
___Barrier Face Treatment
___Limits of Pigmented Sealer
___BP/Pedestrian Rail dimensions
___Stage Construction Lane Orientations
___Locations of Temporary Concrete Barrier
___Closure Pour
___Structure Depth/Prestressed Girder Type
___Conduits/Utilities in bridge
___Substructure Dimensions

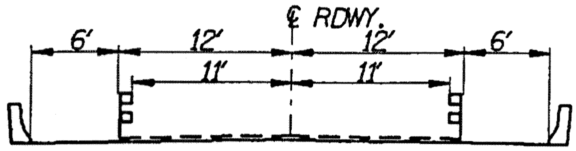
LEFT MARGIN

___Job Number
___Bridge (before/with/after) Approach Fills
___Structure Depth/Prestressed Girder Type
___Deck Protective System
___Coast Guard Permit Status
___Railroad Agreement Status
___Points of Minimum Vertical Clearance
___Cast in Place Concrete Strength

RIGHT MARGIN

___Control Section
___Project Number
___Region
___Highway Section
___SR Number
___Structure Name

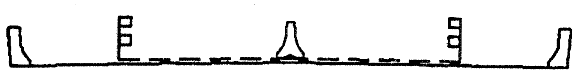
## BRIDGE STAGE CONSTRUCTION COMPARISON



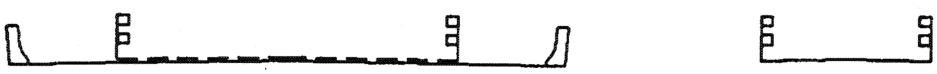

1. NO LANES OPEN: RELATIVE COST FACTOR (RCF) = 1.0

2. TWO LANES OPEN WITH NEW ALIGMENT: RFC = 1.0

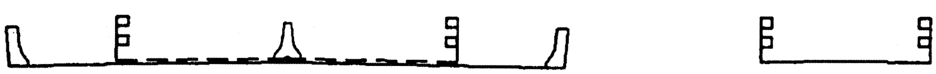
3. ONE LANE OPEN WITH NEW ALIGMENT AND STAGE CONSTRUCTION: RCF = 1.2



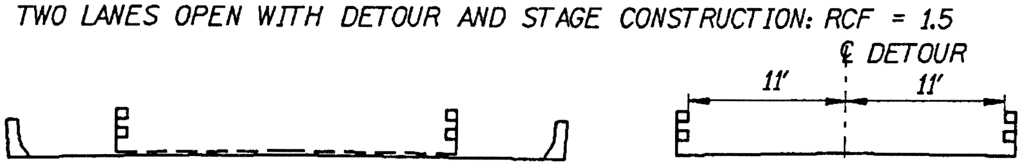
4. ONE LANE OPEN WITH STAGE CONSTRUCTION: RCF = 1.2



5. ONE LANE OPEN WITH DETOUR: RCF = 1.3



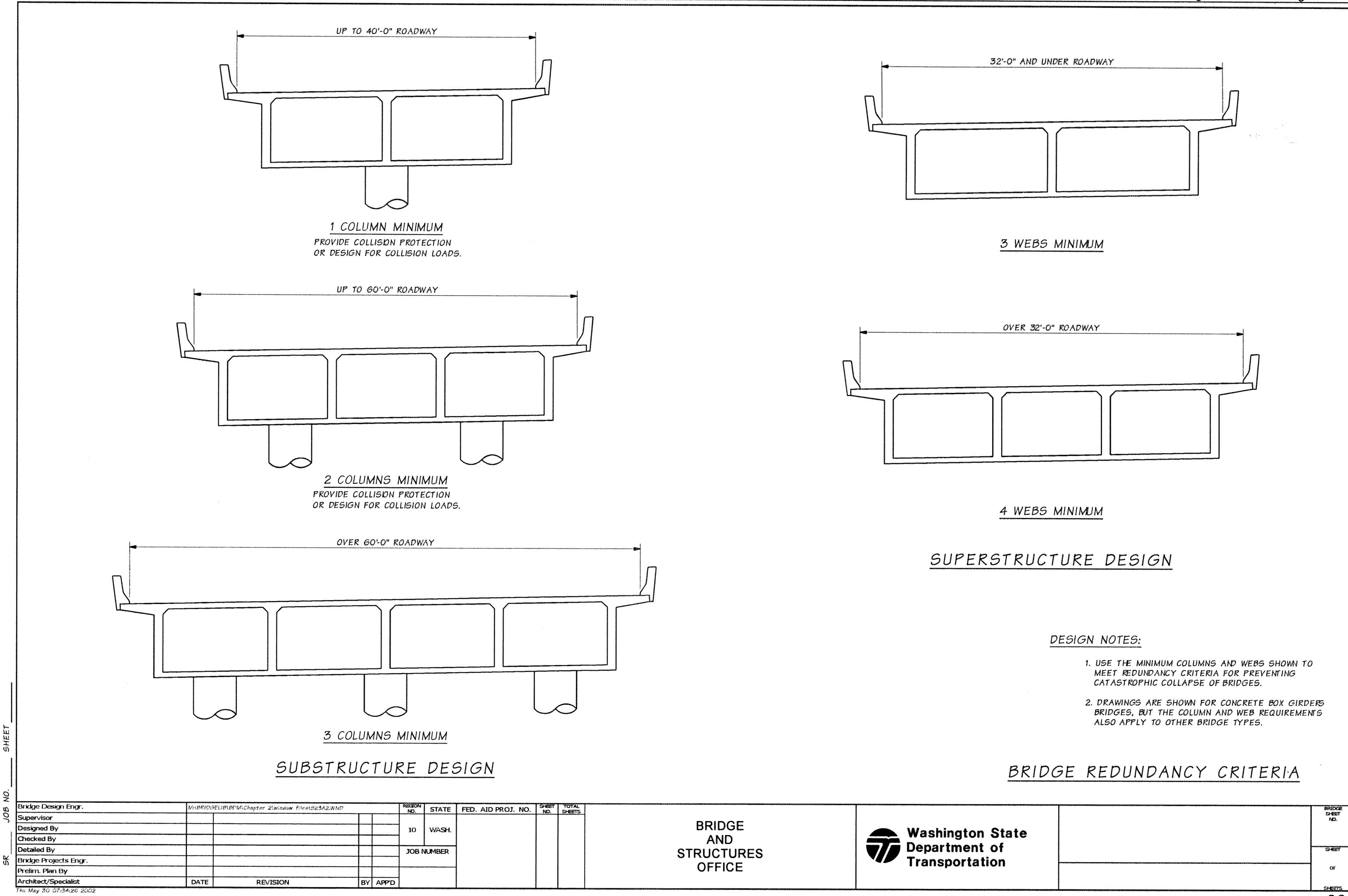
6. TWO LANES OPEN WITH DETOUR AND STAGE CONSTRUCTION: RCF = 1.5



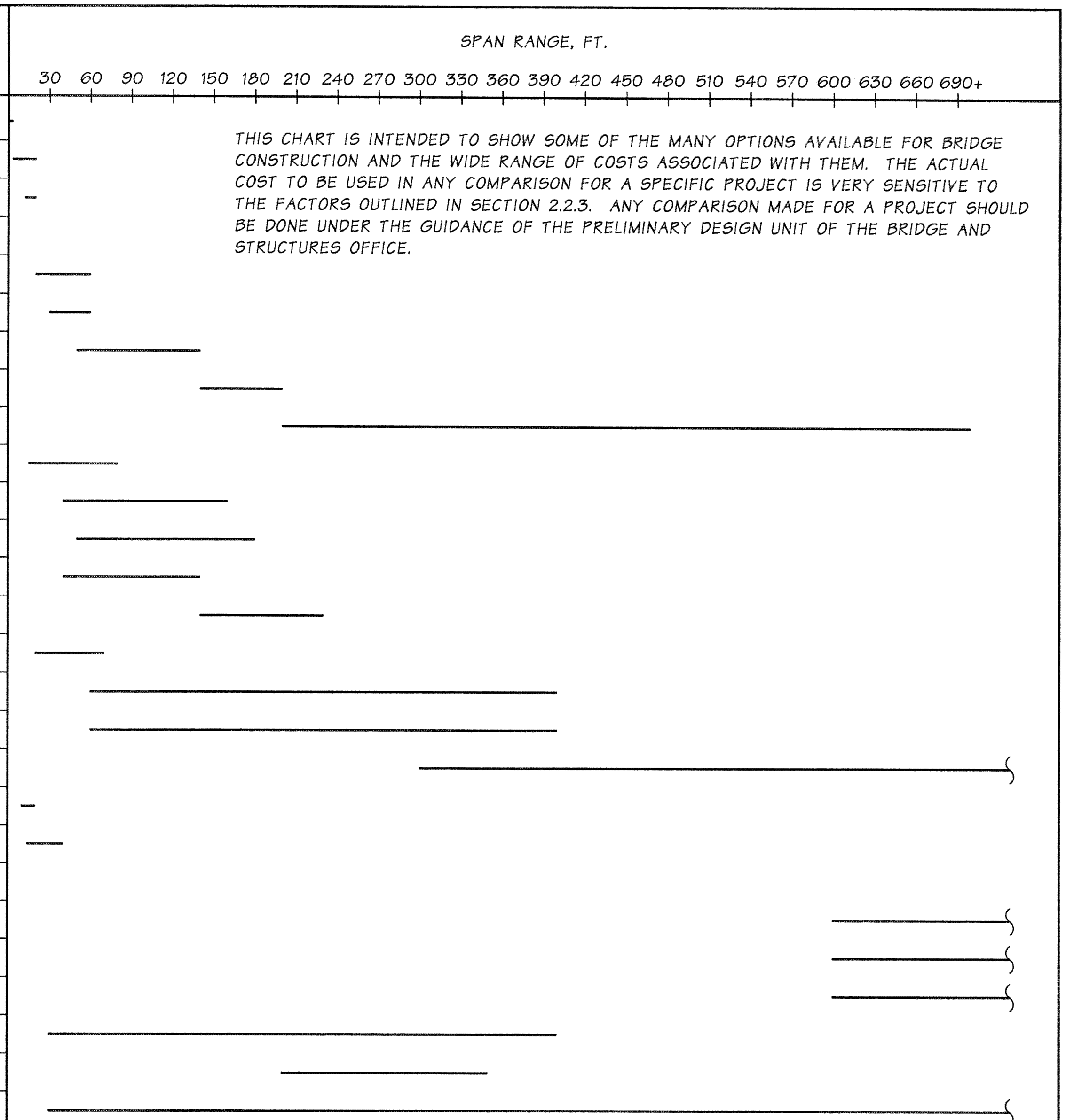

7. TWO LANES OPEN WITH DETOUR: RCF = 1.6

ASSUMPTIONS:
NEW BRIDGE, TWO SPAN PRESTRESSED GIRDER, 200 FT. LONG.
DETOUR BRIDGE, TWO SPAN STEEL GIRDER WITH TIMBER TRESTLES, 200 FT. LONG.
$50/FT WITH 20% PREMIUM WHEN STAGING CONSTRUCTION.

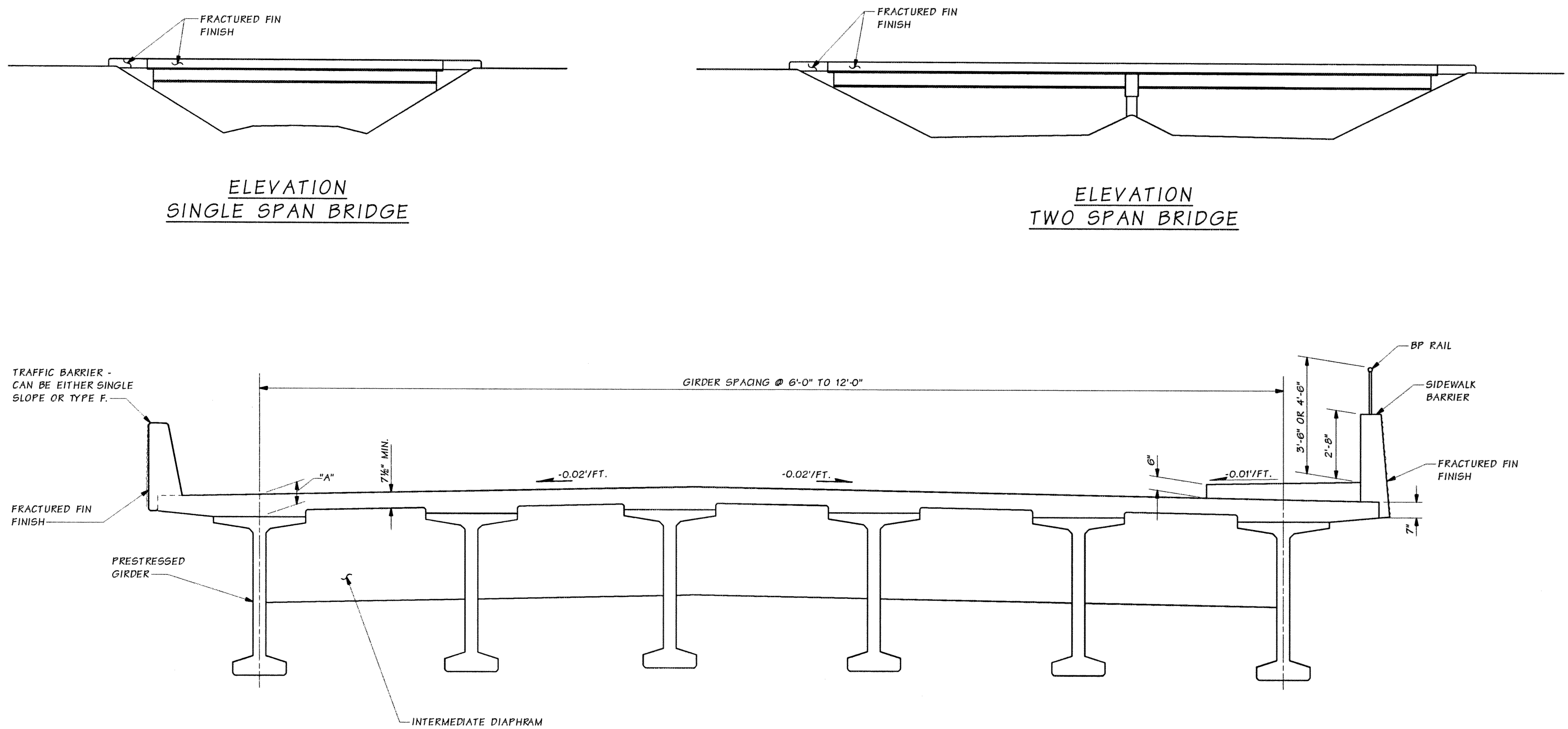
THIS CHART IS INTENDED TO SHOW SOME OF THE MANY OPTIONS AVAILABLE FOR STAGING BRIDGE CONSTRUCTION. THE ACTUAL COST FACTORS FOR A SPECIFIC PROJECT ARE VERY SENSITIVE TO THE FACTORS OUTLINED IN SECTION 2.2.3. ANY COMPARISON MADE FOR A PROJECT SHOULD BE DONE UNDER THE GUIDANCE OF THE PRELIMINARY DESIGN UNIT OF THE BRIDGE AND STRUCTURES OFFICE.


UP TO 40'-0" ROADWAY
1 COLUMN MINIMUM
PROVIDE COLLISION PROTECTION
OR DESIGN FOR COLLISION LOADS.
UP TO 60'-0" ROADWAY
2 COLUMNS MINIMUM
PROVIDE COLLISION PROTECTION
OR DESIGN FOR COLLISION LOADS.
OVER 60'-0" ROADWAY
3 COLUMNS MINIMUM
SUBSTRUCTURE DESIGN
32'-0" AND UNDER ROADWAY
3 WEBS MINIMUM
OVER 32'-0" ROADWAY
4 WEBS MINIMUM
SUPERSTRUCTURE DESIGN
DESIGN NOTES:
1. USE THE MINIMUM COLUMNS AND WEBS SHOWN TO MEET REDUNDANCY CRITERIA FOR PREVENTING CATASTROPHIC COLLAPSE OF BRIDGES.
2. DRAWINGS ARE SHOWN FOR CONCRETE BOX GIRDERS BRIDGES, BUT THE COLUMN AND WEB REQUIREMENTS ALSO APPLY TO OTHER BRIDGE TYPES.
BRIDGE REDUNDANCY CRITERIA
Bridge Design Engr.
Supervisor
Designed By
Checked By
Detailed By
Bridge Projects Engr.
Prelim. Plan By
Architect/Specialist
DATE
REVISION
BY
APP'D
REGION NO.
STATE
FED. AID PROJ. NO.
SHEET NO.
TOTAL SHEETS
10
WASH.
JOB NUMBER
BRIDGE
AND
STRUCTURES
OFFICE
Washington State
Department of
Transportation
BRIDGE SHEET NO.
SHEET
OF
SHEETS
JOB NO.
SHEET
SR

| | STRUCTURE TYPES | SPAN RANGE, FT. | JULY 2002 COST RANGE $ / FT² |
|---|---|---|---|
| HYDAULIC STRUCTURES | PIPE | 1 - 3 | 15 - 45 |
| | CONCRETE CULVERT | 3 - 20 | 75 - 90 |
| | PLATE ARCH | 12 - 20 | 45 - 60 |
| STRUCTURES FOR CONVENTIONAL SITE CONDITIONS | | | |
| | REINF. CONCRETE SLAB | 20 - 60 | 60 - 105 |
| | REINF. CONCRETE TEE BEAM | 30 - 60 | 65 - 110 |
| | REINF. CONCRETE BOX GIRDER | 50 - 140 | 75 - 120 |
| | POST-TENSIONED CONC. BOX GIRDER | 140 - 200 | 100 - 140 |
| | SEGMENTAL P.T. BOX GIRDER | 200 - 700 | 140 - 160 |
| | PRESTRESSED CONC. SLAB | 15 - 80 | 65 - 85 |
| | PRESTRESSED CONC. DECK BULB TEE | 40 - 160 | 60 - 105 |
| | PRESTRESSED CONC. GIRDER | 50 - 180 | 60 - 120 |
| | PRESTRESSED TRAPEZOIDAL TUB GIRDER | 40 - 140 | 120 - 140 |
| | PRESTRESSED CONCRETE SPLICED GIRDER | 140 - 230 | 90 - 140 |
| | STEEL ROLLED GIRDER | 20 - 70 | 85 - 110 |
| | STEEL PLATE GIRDER | 60 - 400 | 105 - 180 |
| | STEEL BOX GIRDER | 60 - 400 | 120 - 200 |
| | STEEL TRUSS | 300 - 1200 | 175 - 275 |
| | TIMBER | 10 - 20 | 60 - 100 |
| | GLULAM TIMBER | 14 - 40 | 70 - 100 |
| STRUCTURES FOR SPECIAL SITE CONDITIONS | | | |
| | CABLE STAY BRIDGE | 600 - 1200 | 200 - 300 |
| | SUSPENSION BRIDGE | 600 - 5000 | 500 - 750 |
| | FLOATING BRIDGE | 600 + | 300 - 600 |
| | ARCH BRIDGE | 30 - 400 | 220 - 250 |
| | MOVEABLE SPAN BRIDGE | 200 - 350 | 1100 - 1500 |
| | TUNNEL | 30 + | 500 - 1500 |




THIS CHART IS INTENDED TO SHOW SOME OF THE MANY OPTIONS AVAILABLE FOR BRIDGE CONSTRUCTION AND THE WIDE RANGE OF COSTS ASSOCIATED WITH THEM. THE ACTUAL COST TO BE USED IN ANY COMPARISON FOR A SPECIFIC PROJECT IS VERY SENSITIVE TO THE FACTORS OUTLINED IN SECTION 2.2.3. ANY COMPARISON MADE FOR A PROJECT SHOULD BE DONE UNDER THE GUIDANCE OF THE PRELIMINARY DESIGN UNIT OF THE BRIDGE AND STRUCTURES OFFICE.




STANDARD SUPERSTRUCTURE ELEMENTS

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Bridge Design Engr. | M:\BRIDGELIB\BDM\Chapter 2\window files\527A1.WND | REGION NO. | STATE | FED. AID PROJ. NO. | SHEET NO. | TOTAL SHEETS | BRIDGE AND STRUCTURES OFFICE | Washington State Department of Transportation |
| Supervisor | | 10 | WASH. | | | | | |
| Designed By | | JOB NUMBER | | | | | | |
| Checked By | | | | | | | | |
| Detailed By | | | | | | | | |
| Bridge Projects Engr. | | | | | | | | |
| Prelim. Plan By | | | | | | | | |
| Architect/Specialist | DATE / REVISION / BY / APP'D | | | | | | | |

BRIDGE SHEET NO.
SHEET OF SHEETS

SR ___ JOB NO. ___ SHEET ___

Thu May 30 05:23:46 2002